Some Energy Conserving Alternatives

User-Controlled Alternatives

- Assume responsibility for managing the use of energy in your own work area
- Lower room temperatures to 20°C during occupancy and to 15° - 18°C at other times
- Use air conditioning only when room temperatures exceed 24°C
- Use available daylight as much as possible
- Maintain all equipment regularly
- Foster energy consciousness through the school curriculum
- Monitor energy use systematically
- Publicize the results of energy-conserving measures

Building-Modification Alternatives

- Automate heating and lighting controls
- Insulate hot water lines
- Insulate heating ducts that pass through unheated spaces
- Convert inefficient lighting systems to more efficient types
- Caulk and weatherstrip doors, windows and cracks
- Double glaze windows
- Install vestibule doors
- Insulate walls and ceilings
- Provide shades or drapes on windows to control the effects of solar heating

Designs For New Schools

- Design buildings in the shape of a square to reduce wall perimeter and roof area
- Locate gymnasium near centre of the building core to reduce exposed wall area
- Construct a building envelope that is as airtight as possible
- Insulate walls and ceilings
- Orient building so windows gain as much solar heat as possible in the winter
- Provide zone control of heating and lighting
- Automate heating, lighting and ventilation controls
- Use variable volume heating and air handling systems
- Use heat recovery systems where feasible

Building Quality Restoration Program (BQRP)

Many of the energy-conserving building modifications to be made to existing schools are eligible for financial support under the Building Quality Restoration Program. For consideration under the BQRP would be:

- addition of roofing insulation when roof replacements are made
- addition of attic and wall insulation when facility modernization occurs
- replacement of insulation for heating, equipment, hot air ducts, and hot water piping
- vestibule enclosures
- automation of heating and lighting controls where feasible

More Information

More detailed guidelines for conserving energy in schools are available from:

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Guidelines for Conserving Energy in Alberta Schools

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Why Save Energy?

Every day we are reminded that we are facing a world-wide energy shortage in the foreseeable future. If we want to preserve our present standard of living beyond the next decade or two we will need to harness new forms of energy or carefully conserve the energy supplies we now have.

Most of Alberta's schools were built before anyone was really concerned about saving energy. As a result, many schools (which are otherwise satisfactory) use more energy than necessary. This of course has two effects — operation of these schools is needlessly costly and the wasted energy only hastens any impending shortage of energy.

For its part in efforts to forestall an energy crisis, Alberta Education has sponsored three energy conservation studies. The results of these studies are available to Alberta educators to enable them to take the initiative in energy conservation in both schools and the community. Guidelines have been prepared, and are available, to show how to realize annual energy savings in our schools of 20 percent or more.

Translated into terms we can all understand, a 20 percent reduction in the annual use of energy in Alberta's schools would result in a saving of energy sufficient to meet the annual energy demands of 11,000 homes. On today's energy market this amount of energy would have a value of about $4,000,000 and the value would increase with future increases in energy prices.

What Is Being Done Now?

Alberta Education has invested $180,000 in three studies of how to conserve energy in schools. The studies look at: ways and means of motivating people to conserve energy, energy-conserving modifications which can be made to existing schools, and design specifications for energy-conserving schools of the future.

- Ways and means of motivating people to save energy are being developed by the Grande Prairie School District in cooperation with the Faculty of Environmental Design of the University of Calgary. When completed late in 1979, this study will have identified ways of increasing the public's awareness of the value of conserving energy and developed programs to show people how to conserve energy.

- The problem of making existing schools more energy efficient is being examined by the Calgary Board of Education and Reid, Crowther and Partners, Limited.

The initial findings of this study point to two conclusions. First, major modifications such as reinsulation of walls and roofs, and other major modifications to schools or their mechanical systems, are best done as part of a more extensive school up-grading program (such as those programs covered by the Building Quality Restoration Program). Second, many small modifications can be made to schools which will increase their energy efficiency. Among those modifications are: installation of automatic controls for heating, lighting, and ventilating systems; addition of vestibules at entrances; caulking and weatherstripping; reduction of lighting levels; use of more efficient lightbulbs; reduction of ventilation rates; and reduced use of air exhaust fans.

- The specifications to be applied to new energy-efficient schools are being developed by the Edmonton Public School Board and Minsos Vaitkunas Jamieson Architects Limited. These specifications have been incorporated into the design of a new school which will be built in Edmonton in 1979. Tests to be conducted on the new school are expected to show that a carefully designed school will require about half as much energy as typical schools built in the early to mid 1970s.

How Can An Energy Conservation Program Be Implemented In Schools?

There are five steps to an energy conservation program:

1. Prepare an **energy inventory** to determine how much energy is currently being used and how much it costs.

2. Prepare an **energy budget** which describes the theoretical energy requirements for each building and establishes a reasonable goal for energy reduction.

3. Conduct an **energy audit** to determine where energy is being wasted. A **mini-audit,** suitable for launching an initial energy conservation program may be conducted by administrators and maintenance personnel. A more sophisticated **maxi-audit** to be used as the basis for a long-range plan should be completed by specially trained personnel or consultants.

4. Prepare an **implementation plan** which examines alternative ways of reducing energy waste. Upon completion of the plan steps should be taken to put the selected energy conservation measures into effect. Measures should include programs designed to change attitudes and behaviors of building occupants as well as modifications to buildings and their components.

5. Develop and implement an **evaluation plan** to prove the effectiveness of the selected energy conservation measures and to collect data for further planning.

Guidelines and materials for completing these steps are now available from Alberta Education, Planning and Research Branch.

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Guidelines for Conserving Energy in Alberta Schools

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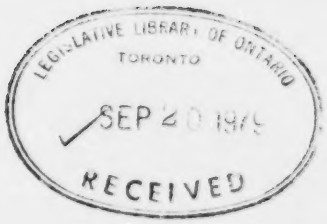
Planning and Research publications have a new look.

Starting with this report, Guidelines for Conserving Energy in Schools, all P & R publications will assume a new cover design.

From now on, you can identify publications prepared by and for the Planning and Research branch of Alberta Education, by a green cover carrying a trademark banner at the bottom.

Energy Conservation 101-065767

GUIDELINES FOR CONSERVING ENERGY IN SCHOOLS



Planning and Research Branch
Alberta Education

1978

GUIDELINES FOR CONSERVING ENERGY IN SCHOOLS

Many of the schools in Alberta were built prior to 1970, during a period when the sources of energy used for heating, lighting and operations were inexpensive and apparently unlimited in supply. As a result, many of the buildings which were designed and built during that period failed to include adequate provisions for energy conservation: schools were often poorly insulated; little attention was given to utilization of outside sources of heat and light; boilers and mechanical equipment were often oversized; and, few if any devices were provided for channeling heat, light and power into discrete areas where and when they were needed.

When energy was cheap and plentiful these considerations were unimportant. Today's increasing energy costs together with the prospect of future energy shortages give energy conservation a higher priority within the total program of school planning. For this reason, Alberta Education has recently invested $180,000 in energy conservation studies. While these studies will not be completed before the end of 1979, the initial findings of these studies justify preparation of this set of guidelines for energy conservation in schools.

Educators today have two responsibilities relating to energy conservation. First, they must assume a role of leadership in energy conservation. This is important because energy, in the forms presently used, is non-renewable and of limited supply. Whether or not the next generation is faced with an acute energy shortage may be determined to a large extent by actions we take today. Secondly, school operating costs should be reduced wherever possible. In many instances these costs can be reduced through energy conservation.

These guidelines are intended to help you develop an effective energy conservation plan for your school or system. The *first section* contains a description of the units of measure used throughout these guidelines. *Section two* of the guidelines describes the preliminary findings of three energy conservation studies. The *third section* describes how an energy conservation program may be developed. *Sections 4, 5 and 6* discuss alternate ways of conserving energy. The *final section* discusses some of the factors to consider in evaluating an energy conservation program. The *appendices* contain charts and forms designed to make data collection and interpretation easier. These forms are adaptable to any jurisdiction--local logos may be added if desired. Master copies of these forms are available on request from the Planning and Research Branch as long as the supply lasts.

ACKNOWLEDGEMENTS

Many people have contributed to the preparation and review of these energy conservation guidelines. Their contributions are gratefully acknowledged.

The most direct involvements have been by members of the Energy Conservation Steering Committee who are guiding the three energy conservation studies currently in progress. This committee includes: J. W. Kulba and J. H. Blocksidge, Alberta Education, School Buildings Branch; M. Holt, Alberta Housing and Public Works; and I. Burn, Alberta Energy and Natural Resources.

The principal investigators in each of the three energy studies reviewed the preliminary drafts of these guidelines. Included are: T. Miner and A. Palmer, Edmonton Public School Board; J. Delaney and N. Patterson, Calgary Board of Education; and, D. Taylor, Grande Prairie School District, with J. Love and others of the Faculty of Environmental Design, University of Calgary.

Among others who reviewed the preliminary drafts and offered useful comments were: D. Monson, Alberta Labour; R. B. Smith and K. Moodie, Alberta Government Services; R. Boisvert, Alberta Power Limited; and, R. Gibbons, H. Coffin, and G. J. Manegre, Northwestern Utilities Limited.

The final draft of these guidelines was reviewed by S. N. Odynak, Associate Deputy Minister, Alberta Education; M. R. Fenske and W. L. Hill, Alberta Education, Planning and Research Branch; and M. Ricard, Alberta Government Services, Public Affairs Bureau.

Finally, the many contributions made by other members of the Planning and Research Branch must be acknowledged with thanks.

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SECTION 1

UNITS OF MEASURE

Metric units of measure are used throughout these guidelines. As an aid to the reader imperial equivalents are included in parentheses. Following are definitions of the more common units of measure.

Area

Area is expressed in square meters (m^2). A square meter is equivalent to 10.764 square feet.

Energy

Energy is expressed in megajoules (MJ). A megajoule is equivalent to 947.81 British thermal units or 0.278 kilowatt hours. The purchase of energy is measured in a number of different units. The more common units are described below while others are described in Appendix A.

Electricity is purchased in kilowatt hours (kwh) with one kilowatt hour equivalent to 3.6 megajoules.

Gas may be purchased in MCF (1,000 ft^3) which is equivalent to 1,129 megajoules or in Therms (T) which are equivalent to 105.5 megajoules.

Light

Light levels are expressed in lux (lx) which are equivalent to 0.0929 foot candles.

Temperature

Temperature is expressed in degrees centigrade (°C).

Degree Days (DD) are used to describe general temperature trends. A Degree Day occurs when the mean temperature for that day falls below 18°C by 1 degree. While measured daily, Degree Days may be aggregated into weekly, monthly or annual totals.

Time

Time is expressed in terms of a 24 hour clock. For example, 07:00 means 7:00 a.m. and 16:30 means 4:30 p.m.

Elapsed time may be expressed as a second (s), mirute (min), hour (h), day (d) or year (a).

SECTION 2

PRELIMINARY FINDINGS OF ENERGY CONSERVATION STUDIES

Three projects have been commissioned by Alberta Education to study energy conservation in schools: 1) ways of managing the use of energy in schools. 2) energy-conserving modifications which can be made to existing schools; and, 3) energy-conserving designs for new schools. None of these present studies are examining solar power, wind power, or other more exotic sources of energy.

Management of Energy in Schools

The Grande Prairie Public School District and the Faculty of Environmental Design at the University of Calgary are engaged in development of a program for management of energy in schools. *The attractiveness of an energy-conserving management program lies in its low cost--few modifications to the building and equipment are required.* In most areas of Alberta electrical energy costs significantly more than natural gas energy. Accordingly, the greatest energy savings may lie with gas systems but the greatest dollar savings will occur in reduced electrical energy consumption by electrical systems. *Preliminary findings of this study suggest that a reduction of 20 percent in total energy costs should be realizable.*

A further potential benefit of an energy management program is that many people will carry good attitudes towards energy conservation from their work place to their homes.

Energy-Conserving Modifications to Existing Schools

The Calgary Board of Education and Reid, Crowther and Partners, Limited have undertaken an examination of energy-conserving modifications which may be made to existing schools.

At the outset of the project the effects on existing schools of a number of major modifications were simulated. Among these simulated modifications were: changes in roof insulation; window blocking and insulating; altered lighting; variable air volumes; reduced ventilation rates; triple glazing of windows; roofed court areas; and, wall insulation.

It was found that most of the schools analyzed in the study were reasonably well constructed. As a consequence few of the simulated modifications were found to be cost-effective for these schools. (To be cost-effective the dollar value of the energy savings as a result of modification should offset the cost of modification in a reasonable period of time, e.g. 10 years.) On the other hand many of the simulated modifications would have been cost-effective if completed in conjunction

with other renovations. For example, extra insulation could be added when a roof is replaced.

The second step of the project was devoted to identification of smaller modifications that could be made to existing schools. Among those identified and selected for testing in two test schools are: reducing hot water temperature; reducing light levels in corridors and classrooms, weatherstripping doors and other openings, time-clock controls on exhaust fans; cycling car plug-ins; and, replacing manual controls with automatic controls on heating and lighting systems where practical.

Subsequent steps involve installation and evaluation of these modifications beginning in the fall of 1978. *On the basis of initial calculations, and supported by studies elsewhere, it appears reasonable to expect that energy savings of at least 20 percent will result from selected plant modifications.*

Energy-Conserving Designs for New Schools

Staff members of the Edmonton Public School District together with the consulting firm of Minsos Vaitkunas Jamieson Architects Limited are developing new school design parameters.

The first step of the project involved analysis of several building components in order to establish optimum specifications. Included were comparisons of: roof systems, wall systems, lighting layouts, glazing areas, mechanical systems, and air supply systems.

In the second step it was determined that the Federal energy consumption standard of 900 $MJ/m^2/a$ (250 kwh/m^2/year or 23 kwh/ft^2/year) was a feasible design target. By contrast it was found that four existing schools which were evaluated had energy consumptions of 1,656, 1,962, 2,466 and 2,743, $MJ/m^2/a$. The current Alberta standard is 1,080 $MJ/m^2/a$ (300 kwh/m^2/year or 28 kwh/ft^2/year) and that of the United States is 720 $MJ/m^2/a$ (200 kwh/m^2/year or 19 kwh/ft^2/year). *By meeting the Federal standard new schools would consume about half the energy of present schools.*

The third step of the project involves design and construction (beginning in the fall of 1978) of a new school in keeping with the findings of the study. Upon completion, the school and its operation will be evaluated and a final report prepared.

Summary

The preliminary findings of the studies sponsored by Alberta Education include:

- better designed schools will reduce annual energy consumption by as much as 50 percent,
- minor modifications to existing school buildings should reduce annual energy consumption by at least 20 percent,
- major energy-saving modifications should be included with other building renovations for additional reduction of energy consumption,
- good management of energy use will lower annual energy consumption by at least 20 percent,
- frequently the greatest dollar savings occur with reductions in the use of electrical energy, and,
- programs which change peoples' attitudes towards energy conservation have an effect beyond the place of work.

The study findings which are most generalizable are those stemming from the study of energy management. They are immediately applicable to every school in Alberta and at little additional cost. Additional energy savings can occur in many schools through selective modifications and repairs. Future energy consumption can be substantially reduced through better school designs.

The guidelines which follow should be examined carefully. Each administrator will probably find that some are more applicable to his particular situation than others. Many administrators will find that it is possible to expand the guidelines thus obtaining greater savings.

It must be recognized that the various forms of energy conservation are not strictly additive. A modification program, which may in itself reduce energy consumption by 20 percent, cannot be coupled with a human management program (also capable of yielding an energy saving of 20 percent) to attain a total energy saving of 40 percent. An overall saving of 30 percent would be more realistic. In the same way a well designed school will not be subject to wide variations in energy consumption as a result of management and operation practices.

SECTION 3

DEVELOPING AN ENERGY CONSERVATION PROGRAM

An energy conservation program has five steps. 1. An energy inventory is carried out to determine how much energy is currently being used. 2. An energy budget is prepared to facilitate more careful planning of energy usage. Included with the energy budget should be specific goals and objectives for the energy conservation program. 3. An energy audit is carried out to determine where energy is wasted. 4. An implementation plan for selection and installation of measures for reducing energy waste is prepared. 5. An evaluation of the selected energy conservation program is completed and forms the basis for a second cycle of planning.

The first four steps of the energy conservation program are discussed in this section. Specific measures for conserving energy are discussed in subsequent sections. Evaluation of the energy conservation program is discussed in the final section.

The Energy Inventory

The purpose of the energy inventory is to determine how much energy is being used in each school or building. An adequate energy inventory can usually be prepared from old energy bills and can be maintained as new bills are received. Appendix A contains a conversion chart which makes it easy to convert most common fuel usages into standard energy units for purposes of planning and comparison. The megajoule (MJ) is rapidly becoming the accepted measure (metric) of energy. Megajoules per square meter per year ($MJ/m^2/a$) is a suitable standard for use in comparing energy consumption of different buildings.

Chart 1 in Appendix B was designed to simplify preparation and interpretation of the energy inventory. Where forms of energy other than electricity and natural gas are used, the chart should be modified accordingly.

The calculation of energy per square unit (MJ/m^2) for each month is not very meaningful because there is a variance month to month and year to year. It is suggested, therefore, that energy use per square unit be calculated on a 12-month rolling average. For those energy conservation projects where attempts are made to correlate daily, weekly, or monthly energy use with degree days or other factors, the rolling average can be replaced with actual figures.

The Energy Budget

An energy budget should provide four types of information: 1) the

theoretical energy consumption for a building; 2) the actual energy consumption; 3) the building efficiency; and 4) the target or planned energy consumption.

Theoretical Energy Consumption

The theoretical energy consumption of a building is computed by multiplying the building area by an accepted standard of energy consumption. The Federal standard has been set at 900 $MJ/m^2/a$ (23 kwh/ft^2/year). In northern areas this may increase to 1,080 or even 1,260 $MJ/m^2/a$ (28 or 33 kwh/ft^2/year). For example, a core school of 3,100 m^2 (33,400 ft^2) would have a theoretical annual energy requirement of 2,790,000 MJ (3,100 X 900) according to the Federal standard. In a northern area the same school may require 3,906,000 MJ (3,100 X 1,260) per year.

Actual Energy Consumption

The actual energy consumption is recorded in Chart 1 and may be divided into electrical and fuel energy consumption.

Efficiency

The efficiency of the building may be computed by dividing the theoretical energy requirements by the actual energy consumed. The efficiency index may be used as one way of ranking buildings for possible energy-saving modifications.

Planned Energy Consumption

A reasonable initial target for planning purposes might be for a 20 percent reduction in total energy consumption. Past rates of consumption will make it possible to set targets for both fuel and electrical energy consumption. It might be expected that less than 10 to 15 percent of the total energy consumption would be in the form of electricity.

It may also be noted that electrical energy frequently costs more (often 4 to 6 times more) than equivalent energy in other forms. As a result, cost-conscious administrators may be able to obtain some quick reductions in operating expenses through reduction in use of electricity--particularly in excess lighting.

The energy budget clearly outlines the scope of an energy conservation program for a building: the theoretical energy consumption; the actual consumption; and the target level of consumption. The energy budget also serves as a standard by which the energy conservation program may be evaluated.

The Energy Audit

An energy audit is intended to identify areas of energy waste in the building and may take one of two forms--a mini-audit or a maxi-audit. The mini-audit is intended to provide the basis for the initial energy conservation program. The maxi-audit provides the basis for a more sophisticated and long-term energy conservation program.

In order that maxi-audits may be completed at a later date, administrators are encouraged to immediately begin compilation of energy consumption and cost records.

The Mini-Audit

A mini-audit amounts to a walk-through inspection of the building with note being taken of obvious building deficiencies. Charts 2 and 3 in Appendix B provide check lists for the more common defects. To a large extent the experience of the inspectors (usually maintenance staff and administrators) determines the success of the mini-audit.

The Maxi-Audit

Usually, a mini-audit will provide enough information to allow design of the initial energy conservation program. After obvious building defects have been taken care of, a maxi-audit--a more thorough inspection of the building--should be completed by a mechanical engineer or someone experienced in energy audits. Often consultants from consulting firms or utility companies are available to do this task. They will also be able to advise on the cost-effectiveness of alternate choices for correcting defects.

A completed energy audit (mini or maxi) prepares the way for preparation of an energy conservation implementation plan.

Planning For Implementation Of The Energy Conservation Program (Office of Energy Conservation, Department of Energy, Mines and Resources, 1977: 7-9)

Upon completion of the energy inventory, preparation of an energy budget (including energy consumption targets), and completion and analysis of an energy audit, specific plans can be made for implementation of an energy conservation program.

Step 1 Correct the housekeeping energy wastes identified in the mini-audit and noted in Charts 2 and 3 of Appendix B.

Step 2 Identify all feasible alternatives for reducing other energy inefficiencies identified in the energy inventory and energy audit. Many of the alternatives are described in subsequent

sections. Each of these sections should be reviewed for potential energy-saving alternatives. Evaluate each feasible alternative and select the most rewarding for early implementation. The most rewarding can be identified by:

- calculating annual energy savings for each alternative;
- projecting future energy costs and calculating annual dollar savings;
- estimating capital or modification expenses;
- evaluating investment merit using measures such as "return on investment" (equation 4 below);
- assigning priority to projects based on investment merit; and
- requesting capital authorization.

Return On Investment

The following are the cost items of modifications designed to conserve or recover energy:

First cost (labour and materials) (FC)
Annual operating cost (in dollars) (AOC)
Projected fuel price (unit price at time of start-up) (PFP)
Estimated lifetime of equipment (EL)
Annual fuel savings (in units) (AFS)
Net annual savings (S)
Pay-back period (in years) (PP)
Depreciation charges (dollar/year) (DC)
Return on investment (% per year) (ROI)

In the following equation, substitute your own figures for the cost items:

$$S = AOC - (AFS \times PFP) \qquad 1$$

$$PP = \frac{FC}{S} \text{ (compare with EL)} \qquad 2$$

$$DC = \frac{FC}{EL} \qquad 3$$

$$ROI = \frac{S - DC \times 100\%}{FC} \text{ (look for 15-20\%)} \qquad 4$$

Summary

This section of the guidelines has dealt with planning for energy conservation in schools. It describes how present energy usage may be appraised through an energy inventory. Preparation of an energy budget containing a description of the theoretical energy requirements for a building, the actual usage, and a target or goal for reduced energy consumption are discussed. The use of energy audits in pinpointing

areas of energy waste is then discussed and followed by a plan for implementing an energy conservation program. A number of potential energy conserving measures are discussed in subsequent sections.

SECTION 4

GUIDELINES FOR MANAGEMENT OF ENERGY USERS

The management of energy users should be a concern of every administrator in every school in the province. The potential exists for reduced energy consumption and reduced energy costs, both without major expenditures. The following guidelines illustrate areas where energy may be saved in schools. Innovative administrators will find other ways of saving additional energy.

Human Management Practices

Work cooperatively with teachers, students, caretakers and maintenance personnel in the implementation of energy conservation measures. To gain acceptance, measures used to conserve energy must accomodate preferences (within reason) of all those people who are affected.

At the outset, a note of caution must precede the recommendation of the following measures. The measures specified below are often maximum initiatives to be taken; their implementation must be tempered with a knowledge of circumstances in each building--both physical characteristics and user needs. The most effective means of dealing with such circumstances is by delegating responsibility to the local school administration for specific implementation of measures which will affect local users.

To give a concrete example of specific considerations which would require some thought before measures could be adopted, consider nighttime thermostat set back. It is evident that special provisions would have to be made for tropical fish and other temperature sensitive animals kept in schools when this measure is applied.

1. Monitor people's efforts and give them specific feedback on their performance. This may entail installation of some meters and monitoring devices. Forms such as shown in Appendix B may be useful.

2. Assign people responsibility for their work spaces.

    a. Teachers should see that classroom lights are switched off when rooms are vacant (recess, noon, after school).

    b. Shop instructors should selectively switch off lighting when only portions of their shops are in use. Exhaust hoods should be operated as little as possible in winter, late autumn and early spring. During cold weather, use of exterior doors should also be minimized. Equipment should be operated in an efficient manner.

c. The evening caretaking crew should set thermostats at night-time levels of 15° - 18°C at 16:00 hours (4:00 p.m.).

d. The day caretaking crew should set thermostats at daytime levels (20°C) during the morning round of classroom checks (at 07:00 or 7:00 a.m.). Thermostats enclosed in protective cases should be checked weekly, where possible.

e. Staff should attempt to be economical in setting thermostats. Wearing a sweater is frequently preferable to turning up the heat.

3. Publicize the energy conservation program and results of energy consumption monitoring so that all groups within the school and community are aware of efforts and achievements. (Some suggested forms are included in Appendix B.)

Maintenance and Operations

Year-Round

1. Substitute daylighting from existing windows and skylights for electrical lighting where feasible.

2. Minimize use of electric lighting systems. Lights should be turned off in all unoccupied areas at all times.

3. During cleaning, lights should only be used in the working area.

4. Ensure that all windows are firmly closed (check daily at 16:00).

5. Ensure that both outside and vestibule doors are firmly closed (check daily at frequent intervals, especially after periods of heavy traffic).

6. Ensure that leaking hot water taps are repaired.

7. Lower hot water settings to the range of 38° - 42°C.

Seasonal Operating Practices--Summer

1. Shut off all space heating systems.

2. Shut off hot water heating systems where possible.

3. Shut off ventilating systems for unoccupied areas.

4. Shut off air conditioning for unoccupied areas. In occupied spaces, operate air conditioning from 10:00 to 15:00 or only long enough to avoid significant discomfort. The start-up time will vary with the time of sunrise and the extent of heat build-up in the building.

Seasonal Operating Practices--Fall/Spring

1. Set thermostats back to 15° - 18°C daily at 16:00 (except in areas where warmer temperatures are required).

2. Set thermostats to 20°C at 07:00 each morning that classes are held.

3. In air-conditioned spaces, operate the cooling system from 10:00 to 15:00 or as required to maintain a reasonable comfort level, and only during working days. Maintain temperatures in cooled spaces at 24°C or higher.

4. Shut off ventilating systems daily at 16:00. (This may be delayed for gymnasia and other areas used in the evenings.)

5. Turn on ventilating systems at 08:00 each day that classes are held.

6. Ensure that corridor thermostats are never set above 18°C.

Seasonal Operating Practices--Winter

1. Set thermostats to 20°C at 07:00 each morning that classes are held.

2. Ensure that thermostats are set no higher than 15° - 18°C when schools are not in use (check daily at 16:00). Care must be exercised to ensure that motors and water pipes located near walls do not freeze as a result of lowered temperatures.

3. Ensure that corridor thermostats are never set above 18°C.

4. Shut off air cooling systems.

Maintenance Practices

Electrical

1. Ensure that burnt out lights are replaced immediately.

2. Ensure that luminaires and bulbs are cleaned annually.

3. Replace all fluorescent bulbs every four years.

Mechanical

1. Ensure that controls are calibrated and in good condition.

2. Clean air filters monthly.

3. Lubricate motors and other rotating equipment monthly (or as recommended by manufacturer).

4. Adjust outside air dampers for proper closure. (Some air by-pass may be required for proper functioning of the mechanical system. A mechanical engineer should be consulted.)

5. Adjust heating equipment to ensure maximum combustion efficiency.

6. External door mechanisms should be removed so that doors will not stay open.

7. Clean strainer screens in water circulating systems at two month intervals.

8. Reduce air duct leakage.

9. Repair water leaks.

Structural

1. Repair/seal broken windows.

Organization of the Energy Management Program

District Functions

1. Receive and assess periodic reports on energy consumption from schools. (Forms such as those shown in Appendix B may be useful).

2. Produce and distribute monthly energy use reports to the Board and to each school (including cost estimates).

3. Ensure that energy management measures are being implemented at each school.

4. Provide technical assistance in implementing energy conservation measures. Included should be staff training and provision of incentives.

5. Obtain the mean daily temperatures from the nearest weather office and calculate the weekly average. Provide these data to the schools. Alternately, daily, weekly or monthly degree days may be used in analyses and evaluations of energy conservation measures.

6. Check school energy consumption (monitor meters) at month-end in June, July and August.

7. Ensure that equipment is switched off in July and August.

8. Ensure that maintenance personnel have operating manuals for all equipment and have been trained to operate them.

9. Institute energy consciousness into the system's curricula. Gaul and Kynell (1978) describe one such program.

    We set as our goals:

    - Helping students become good observers of the role of energy in their daily lives;

    - Creating the realization that no form of energy production is without its impact on both the physical and social environment;

    - Creating an awareness of the multi-faceted problem of moving energy from its place of origin to its place of consumption; and

    - Establishing a general knowledge of the practicalities and wide-ranging effects of various approaches to conservation.

    A class schedule was set up for dealing with four primary areas concerning energy:

    - Utilization (three class periods)--use of energy in manufacturing, agriculture, transportation, the home, recreation, defense, etc.

    - Production (five class periods)--general energy-conversion concepts, present and future sources and how they work, environmental trade-offs (including the concept of risk-benefit evaluation).

    - Distribution (three class periods)--mining and drilling, geographical distribution of resources, transportation (unit trains, pipelines, tankers, etc.), electrical transmission, waste handling.

- Conservation (four class periods)--future consumption levels, roles of industry, government, consumer groups and individuals, environmental effects.

Methods used to communicate the subject matter included classroom lectures and demonstrations, films, commercial film strips, simulation games, outside speakers, and student research projects.

School Functions

1. Ensure implementation of energy conservation measures.

2. Ensure that all staff are aware of their responsibilities with respect to energy management and adequately trained to carry them out.

3. Read gas and electricity meters daily.

4. Keep track of daily, weekly or monthly energy performance by using charts comparable to those suggested in Appendix B.

5. Evaluate performance by comparing energy use to building activity schedule and climatic conditions.

6. Display plots of weekly or monthly performance in high traffic/high visibility areas.

SECTION 5

GUIDELINES FOR MODIFYING SCHOOLS TO CONSERVE ENERGY

Bearing in mind that many schools were built when energy was plentiful and cheap, it is easy to see how modifications to otherwise satisfactory schools could lead to more efficient energy utilization.

Major renovations such as roof or wall insulation should probably be carried out only in conjunction with other modifications such as re-roofing or replacement of siding. Many of the more minor modifications to schools should be considered first.

A number of steps are identified which facilitate planning for energy conservation in schools.

1. Classify each school as either "heating only" or as "heating and cooling" depending on whether mechanical refrigeration provides the cooling. Rank all schools in each classification from the highest to the lowest energy consumers. Use standard measures such as megajoules per square meter per year ($MJ/m^2/a$). An alternate would be $\$/m^2/a$.

2. Ensure that the equipment in each school is fully operational. Air and heating water distribution systems should be balanced and measured results reported. Control systems and control devices should be checked and tested. Mechanical and electrical systems should be given a "tune-up". Provide operating and maintenance manuals to users and instruct operating personnel in the proper operation of the systems.

3. For all schools classified under "heating and cooling" (Step 1 above) identify the mechanical system type or types and outline the work required for changing to more efficient mechanical systems if changes are appropriate. It is anticipated that this activity would take place over a long period of time and as energy costs increase the work would progress up the ranking list. A general recommendation as to the most effective mechanical system to apply cannot be made due to the unique designs of schools and their mechanical systems. Decisions for change, and design of these changes, will have to be made on an individual basis.

4. For all buildings classified as "heating only" (Step 1 above) the roof and window insulation should be compared to existing standards and to existing programs for maintenance and blocking-off of windows. Decisions and schedules for carrying out this work can then be made and implementation initiated.

A number of modifications are identified below. While not all will be applicable to every school, each should be considered for its potential impact on the energy budget.

Heating, Ventilation, Air Conditioning

1. Install automatic thermostatic controls for zone control where feasible. Classrooms and offices should be set to 20°C, shops and corridors to 18°C and workrooms and other infrequently used areas to 16°C. Air conditioning should be set to cut in at 24°C or higher.

   When areas are unoccupied, temperatures should be set back to minimum acceptable levels.

   NOTE: If these controls are not automatic, procedures should be developed for manual control.

2. Replace grossly inefficient heating/cooling systems with more efficient systems. Careful cost-benefit calculations should be undertaken prior to taking this step.

3. Reduce air circulation and return to the fewest changes per hour permitted by regulations.

4. Install drapes, shades, fans, etc. to conserve heat or coolness.

5. Insulate heating ducts except those running through heated areas.

6. Minimize the use of exhaust fans and exhaust hoods that exhaust air to the outside.

7. Use properly sized motors. These should be checked when replacement is required.

8. Ensure that the electrical power factor exceeds 90 per cent.

Lighting and Electrical

1. Change incandescent to fluorescent lighting or other more efficient lighting.

2. Remove unneeded fluorescent bulbs from fixtures. Remove unused incandescent bulbs only when empty sockets are to be covered.

3. Install zone switching as an alternative to centrally located circuit-breaker control.

4. Reduce light levels in various areas to minimum. Recommended standards are given in Appendix C.

5. Install photo-sensitive control switches on outside lights.

6. Use task lighting instead of general lighting where appropriate.

7. Install flip-flop connections and timers on car park receptacles. Thirty minute on and off periods from 13:00 to 18:00 and when temperatures fall below -18°C are recommended.

Water and Other Utilities

1. Install timers to turn off hot-water heaters and/or hot-water recirculation systems after hours.

2. Insulate hot-water lines and hot water storage tanks.

3. Reduce flow from shower heads or install automatic duration control for showers. A flow of .227ℓ/s (3 gal/min) with mixed temperature control should be satisfactory.

4. Reduce the number of cycles per hour on automated urinals to the minimum and turn off when not in use.

5. Installation of self-closing faucets on wash basins may be suitable in some locations.

Structural

1. Insulate walls and ceilings. Often, this is best completed as a part of a renovation program.

2. Caulk, weather strip and draft-proof all windows and doors.

3. Double glaze windows.

4. When redecorating, use light colors on walls and ceilings of work areas.

5. Install vestibule enclosures which include two sets of doors.

SECTION 6

GUIDELINES FOR THE DESIGN OF NEW SCHOOLS

The third way in which energy may be conserved is through better school designs. The following guidelines should be considered when a new school is being designed.

The primary objective is to design a school which will, firstly, fulfill the functional needs, and secondly, that the efficiency of the design with regard to conservation of energy is within suitable guidelines. To meet the guidelines set out by the Federal Government, the design of the school must have an energy efficiency of 900MJ/m^2/a (23 kwh/ft^2/year).

Performance of the Building Structure (Envelope)

In the building design, consideration should be given to the following guidelines.

1. The shape of the building should represent a square as nearly as possible to reduce perimeter wall area and roof area.

2. Locate the gymnasium toward the center of the building core to reduce exterior wall area.

3. Provide better wall and roof insulation.

4. When using glazing, orientate the building to maximize on solar heat gain as much as possible in winter and reduce solar heat gain in the summer.

5. Use double glazing as a minimum.

6. Provide vestibules in all entrances to minimize infiltration of outside air.

7. Construct the envelope in an airtight manner--seal all cracks to reduce infiltration.

8. Carefully place insulation along perimeter foundations and carry continuity to wall insulation.

9. In side-lit buildings:

    a. If the view to be obtained is of such value that large windows should be employed, install shading devices such as automatically operated blinds.

    b. Make the most of the glazing used; consider spacing windows and providing splayed reveals so that:

- the windows appear as large as possible when viewed from inside, and
- the maximum of light flows into the building with the minumum of dark spaces between windows.

c. Consider the use of tinted glass.

The Efficiency of the Mechanical System

In design of the mechanical system, consideration should be given to the following:

1. Automated central control system. The use of energy optimizing controls on heating and air conditioning systems should be considered.

2. Modular equipment.

3. Variable volume systems.

4. Induction systems.

5. Reduction of room temperatures from 22°C to 20°C.

6. Shutting down domestic hot water heating during off days and nights.

7. Insulating hot water pipes.

8. Reduction in domestic hot water temperatures from 60°C to 38°C - 42°C.

9. Use of heat recovery loops when a five-year payback can be realized.

10. Reduction in overall ventilation air.

11. Reduction in fresh air and application of better filtration system.

12. Reduction in equipment running time.

The Efficiency of the Electrical and Lighting Systems

In the design of the electrical system, consideration should be given to the following.

1. Reduce lighting levels in all areas to those recommended by the local district or as recommended in Appendix C.

2. Incorporate multi-level switching into instructional areas to allow the instructor to reduce or increase lighting levels as the tasks

being performed by the students change. Provide two-level switching in the gymnasium, e.g. low level for calisthenics and high level for competitive sports. Cleaning could be accomplished with a low light level throughout the areas mentioned.

3. Incorporate some form of automatic lighting controls to reduce lighting levels in corridors during class time, increasing same between class changes.

4. Utilize lenses in light fixtures that have a high efficiency to allow lighting loads to be reduced but still maintain lighting levels.

5. Provide flip-flop connection to car park receptacles to allow only half to be on at a time. These could alternate every thirty minutes.

Environmental Expectations

Large energy savings can be realized by reducing ventilation and lighting levels. School Boards may agree to a lowering of environmental standards, provided that ventilation and lighting systems are such that the quality is not an impediment to the learning environment.

Mechanically, the ventilation system may be reduced to 40 percent of present standards. This reduction is in keeping with the American Society of Heating, Refrigeration and Air Conditioning Engineers' Guide 90-75 and is sufficient to assure odor control and proper oxygen levels.

Similarly, the lighting levels may be reduced below customary illumination. However, built-in multi-level switching gives the user the choice of selecting the proper illumination.

SECTION 7

EVALUATING THE ENERGY CONSERVATION PROGRAM

Each energy conservation project or program will probably have two components: a management program wherein energy users are motivated to use less energy; and a modification program designed to make buildings more energy efficient. In turn, these programs and projects should be evaluated for three reasons: to obtain information to feed back to users so they can see the results of their actions; to measure the effectiveness of selected modifications; and, as a basis for future planning.

Energy users (the building occupants) are best motivated to reduce energy consumption when they can see that their actions have an effect or produce results. Accordingly, one element of the evaluation plan should include collection and circulation of these results. Appendix B contains some suggested forms and charts for collection and interpretation of these data. Other charts contained in Appendix B may be used to communicate these data and findings to both the users and the senior administrators.

Each of the selected modification projects should include an evaluation plan. These evaluations have two purposes. First, the effectiveness of the project or modification is proved or disproved. Secondly, the degree of effectiveness can be used as a guide in subsequent plans for other sites.

The detailed project evaluation can only be designed as part of the total energy conservation project because each project will be unique. In some cases, detailed data will have to be collected over a period of time to verify effectiveness of the projects. For example, a series of daily electricity meter readings could be taken prior to launching a program designed to encourage classroom teachers to take responsibility for controlling lights in their classrooms. A second series of readings taken after the program is underway could then provide the basis for assessing the effectiveness of the venture.

In other cases special measuring devices may have to be installed temporarily. For example, the effectiveness of a program involving reduction of hot water temperature could be evaluated by measuring the average daily fuel consumption by the water heater before and after the change.

As in most other endeavors, it will be the innovative administrators who design the best evaluations and perfect the best techniques for proving the effectiveness of each step of their energy conservation programs. As these techniques are perfected, and others become aware of them, the general level of energy conservation program evaluation will rise.

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APPENDIX A

CONVERSION FACTORS

AND ENERGY EQUIVALENTS

Conversion Factors

1 tonne (t)	= 1,000 kilograms; = 0.985 long ton; = 2,205 lb; = 300 U.S. gals; = 250 Cdn. gals; = 7 barrels (bbl)
1 barrel (bbl)	= 42 U.S. gals; = 35 Cdn. gals
1 ton (short)	= 2,000 lb; = 0.893 long ton
1 cubic foot (ft^3)	= 6.25 Cdn. gals
1 MCF	= 1,000 ft^3
1 metre (m)	= 39.37 in; = 3.28 ft
1 square metre (m^2)	= 10.764 sq ft
1 cubic metre (m^3)	= 35.3 cu ft
1 Btu	= 1,054.8 joules (J)
1 megajoule (MJ)	= 947.813 Btu; = 0.278 kwh
1 Therm (T)	= 105.5 MJ; = 100,000 Btu
1 kilowatt hour (kwh)	= 3.6 MJ; = 3,412 Btu
1 footcandle	= 10.76 lux (lx)

Energy Equivalents

Fuel Type	Unit	Btu per Unit ('000 000)	MJ per Unit
Cdn Bituminous	Short ton	25.2	26,588
Lignite	"	13.2	13,927
Coke	"	24.8	26,165
Liquified Pet. Gases	bbl (35 Cdn. gals)	4.095	4,320
Crude Oil	"	5.803	6,123
Motor Gas	"	5.222	5,510
Diesel Oil	"	5.828	6,149
Light Fuel Oil	"	5.828	6,149
Heavy Fuel Oil	"	6.287	6,633
Aviation Gas	"	5.051	5,329
Aviation Turbo Fuel	"	5.451	5,751
Propane	"	3.8	4,009
Butane	"	4.3	4,537
Natural Gas	1,000 ft^3 (MCF)	1.07	1,129
	100 Therms (T)	10.0	10,550
Electricity	1,000 kwh	3.412	3,600

A P P E N D I X B

CHARTS AND FORMS FOR THE ENERGY INVENTORY AND ENERGY AUDIT

(Sets of these charts can be obtained from the Planning and Research Branch and duplicated as required. Logos may be added locally, if desired)

Chart 1 Energy Consumption Analysis

School or Building: _____

Address: _____ Area: _____ m^2

Energy Budget Theoretical: Total ____ $MJ/m^2/a$; Electrical ____ $MJ/m^2/a$; Fuel ____ $MJ/m^2/a$; Water _____ gals/a

Target: Total ____ $MJ/m^2/a$; Electrical ____ $MJ/m^2/a$; Fuel ____ $MJ/m^2/a$; Water _____ gals/a

Building efficiency: ____%

Conversions

Elec: 1000 kwh = 3600 MJ
Gas: 1 MCF = 1129 MJ
100 T = 10550 MJ
Water: 1 ft^3 = 6.25 gals

Year 19__

		January	February	March	April	May	June	July	August	September	October	November	December	Total	Percent of Total
Elec	kwh														
	MJ														
	$														
Fuel	MCF/Therm														
	MJ														
	$														
Water	gals														
	$														
Total	MJ														100.0
	MJ/m^2*														
	$														

Year 19__

Elec	kwh														
	MJ														
	$														
Fuel	MCF/Therm														
	MJ														
	$														
	gals														
	$														
Total	MJ														100.0
	MJ/m^2*														
	$														

*Based on average of last 12 months.

Chart 2

Energy Audit Checklist

School Jurisdiction: _____

Address: _____

Inspector(s): _____

School or Building	Fuel, Gas or Oil Leak	Steam Leak	Compressed Air Leak	Condensate Leak	Water Leak	Inadequate Insulation			Excess Lights	Unneeded Equipment	Burners out of Adjustment	Unneeded Heating/ Air Cond	Other	Date of Audit
						Wall	Ceiling	Other						
													A	

Chart 3 Energy Conservation Checklist

School or Building: _____ Date: _____

	Yes	No	Comment
STEAM SYSTEMS			
Steam at _____psi, _____pounds per hour (pph) winter peak, _____pph summer demand			
1. Is steam being used at proper pressure for the application?	____	____	_____
2. Is piping insulation adequate?	____	____	_____
3. Are all steam traps operating properly?	____	____	_____
4. Are additional steam traps needed?	____	____	_____
5. Is all condensate returned to the boiler?	____	____	_____
6. Can thermal fluids be used for more efficient heating?	____	____	_____
Comments: _____			
AIR MANAGEMENT SYSTEMS			
1. Are proper temperatures maintained both summer and winter?	____	____	_____
2. Is humidity control adequate for the operation?	____	____	_____
3. Is the area properly insulated to minimize heat loss?	____	____	_____
4. Are exhaust ducts located close to the source of fumes?	____	____	_____
5. Is provision for make-up air adequate?	____	____	_____
6. Is exhaust from processes such as spray booths automatically controlled?	____	____	_____
7. Can the amount of exhaust air be reduced?	____	____	_____
8. Is heat recovered from exhaust air?	____	____	_____
9. Can heat loss be reduced from doors, windows?	____	____	_____
10. Can timers control heaters, fans, chillers more efficiently?	____	____	_____
Comments: _____			
COMPRESSED AIR			
Consumption: _____cfm at _____psi			
1. Are there any leaks in compressed air piping?	____	____	_____
2. Can small compressors handle after-hour loads?	____	____	_____
3. Is compressed air properly dried at the compressor?	____	____	_____
4. Is compressed air properly lubricated where needed?	____	____	_____
5. Is oil-free air supplied where necessary?	____	____	_____
6. Are compressed air pressures properly matched to the application?	____	____	_____
7. Can lower-pressure air be substituted for high-pressure air?	____	____	_____
Comments: _____			
ELECTRICITY			
Voltages available _____, _____, _____, peak electrical demand _____kw			
Total hp of induction motors _____hp, power factor _____%			
1. Can peak demand be reduced by cycling non-critical loads?	____	____	_____
2. Is power factor correction adequate?	____	____	_____
3. Should synchronous motors be used on larger loads?	____	____	_____
4. Is voltage adequate on all circuits?	____	____	_____
Comments: _____			

	Yes	No	Comment

LIGHTING

Lights supplied by (no.) _____ (type) _____ fixtures rated at _____ watts

1. Is lighting at recommended levels for the types of activities in each area? ____ ____ _____
2. Who is responsible for turning off lights when not needed?

   _____
3. Are lighting circuits designed to allow minimal safety lighting? ____ ____ _____
4. Can timers, photoswitches, control exterior lighting? ____ ____ _____
5. Can incandescent lights be replaced with more efficient types? ____ ____ _____

Comments: _____

_____

Chart 4 Daily Energy Consumption Readings

School:

Address:

Month of: _____ 19 ____[1]

Date	Electricity[4,5] demand kilowatts	Electricity[4,5] maximum demand kilowatts	Electricity[4,5] meter reading kw hours	Oil[6] gallons	Gas[5] 100 cubic ft	Water[5] 100 gallons	Remarks: Note any unusual factors affecting energy requirements (after hours activities, equipment breakdown...)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

Instructions

1. Ensure that month and year of this record are noted.
2. Take readings at the same time each day (including Saturdays, Sundays, if feasible).
3. Enter readings in all applicable columns.
4. When reading electrical demand meters note that the red needle indicates "demand" and the black, "maximum demand".
5. Electrical, gas and water consumption are read from dials, left to right, and should be recorded to the nearest whole number. Don't calculate daily consumptions, simply record the cumulative total each day.
6. Oil reading figures will decrease, since the dial indicates the number of gallons remaining in the tank.

Chart 5 Annual Energy Consumption Summary

School Jurisdiction: _____

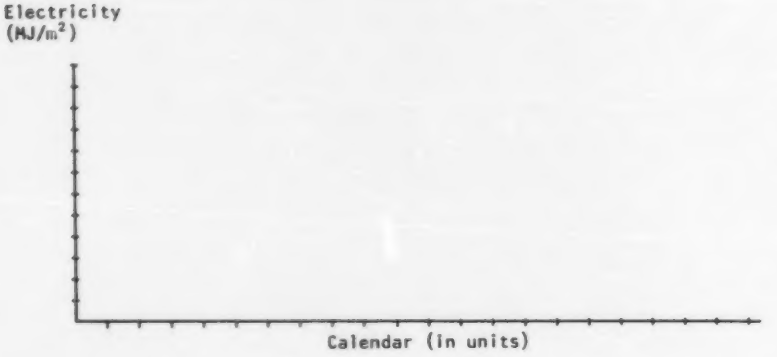
Address: _____

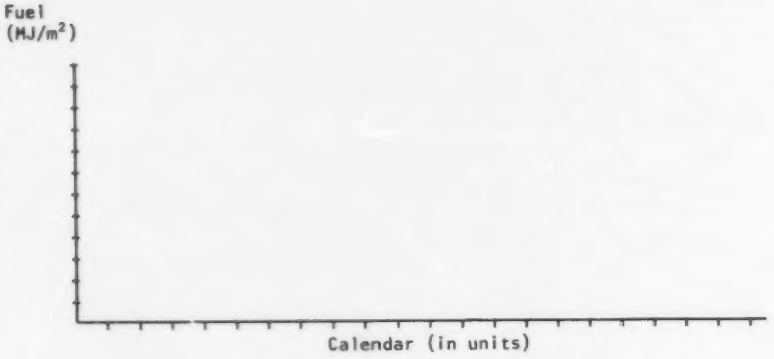
For Period _____ to _____

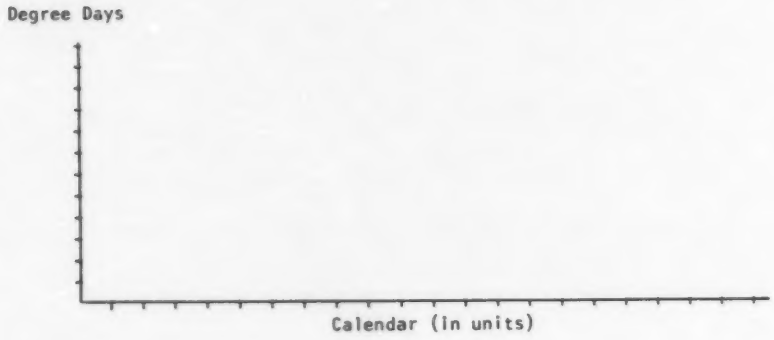
School or Building	Total Hours of Operation	Gross Area (m^2)	Annual Degree Days (DD)	Water (gals)	Energy Consumption			MJ/m^2	$MJ/m^2/DD$	Remarks
					Elec (MJ)	Fuel (MJ)	Total (MJ)			

Chart 6

Our Weekly Energy Consumption*







* May be prepared as a wallchart.

APPENDIX C

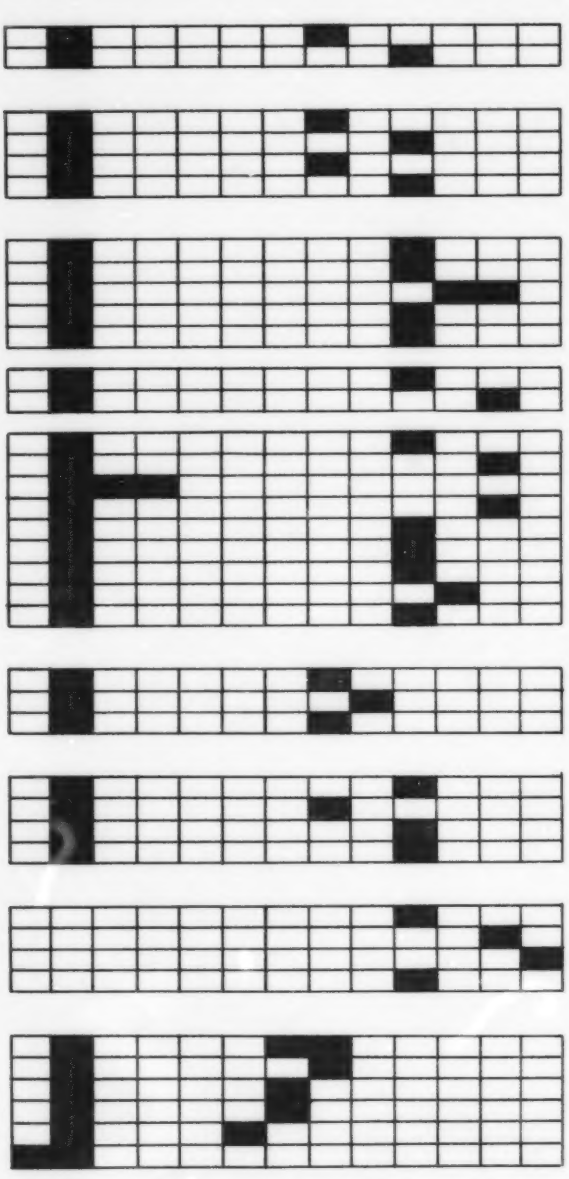
RECOMMENDED LIGHTING LEVELS

RECOMMENDED LIGHTING LEVELS

FOR VARIOUS LOCATIONS IN SCHOOLS

Recommended Lighting Levels

Lux	6	10	11	22	50	160	220	330	540	760	1100	1600	2200
Foot-candles	0.5	0.9 (safety)	1	2	5	15	20	30	50	70	100	150	200



Location

Auditoriums (seating area only)[1,2]
- Assembly only
- Study halls

Cafeterias[1]
- Eating only
- Study halls
- Food displays
- Kitchens

Classrooms[1]
- Regular classroom work
- Art rooms
- Chalkboards (supplementary illumination)
- Drafting rooms
- Home Economics rooms
- Laboratories
  - General
  - Close work
- Lecture and demonstration rooms
  - General
  - Special exhibits and demonstrations
  - Projection[2]
- Lipreading classrooms
- Music rooms
- Manual arts rooms
- Sewing rooms
- Sightsaving classrooms
- Typing rooms

Gymnasiums[1]
- General exercising
- Exhibition sports
- Locker and shower rooms

Libraries[1]
- Reading rooms and carrels
- Stacks
- Book repair and binding
- Check-in, check-out, catalogs, card files

Offices
- Regular office work
- Accounting, auditing, tabulating
- Cartography, designing, detailed drafting
- Conference rooms

Other
- Corridors and stairways[3,4]
- Toilets and washrooms[4]
- Storage rooms[4]
- Service rooms and laundry areas[4]
- Exits[3,4]
- Parking lots

[1]Emergency lighting may be required (10 lux minimum).
[2]Dimming equipment desirable.
[3]Emergency lighting normally required (10 lux minimum).
[4]Provincial regulations apply.